Program for the Development and Dissemination of Sustainable Irrigation Management in Olive Growing (IRRIGAOLIVO) (CFC/IOOC/06)

Annual Report (January-December 2011)

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Project general information

**Project name:** Program for the Development and Dissemination of Sustainable Irrigation Management in Olive Growing (IRRIGAOLIVO) (CFC/IOOC/06)

**Supervisory body:** International Olive Council (IOC)

**Financing body:** Common Fund for Commodities (CFC)

**Counterparts:**
- General Commission for Scientific Agricultural Research (GCSAR) in Syria
- Institut National de la Recherche Agronomique (INRA) in Morocco.

**Project Executing Agency:** International Center for Agricultural Research in the Dry Areas (ICARDA)

**Technical Consultants:** Instituto de Agricultura Sostenible (IAS-CSIC), Spain and Istituto per i Sistemi Agricoli e Forestali del Mediterraneo (CNR-ISAFOM)

The project general structure is given in the Figure below.

**Project Cost:** 1,431,300.00 US$

- CFC contribution: 799,460.00 US$
- Counterparts’ contribution: 631,840.00

**Project duration:** 48 months (Starting January 2010)
I. Background

The IRRIGAOLIVO project focuses on the technology transfer of irrigation best practices to two Mediterranean olive growing countries, Morocco and Syria. Irrigation is expected to complement rather than replace the existing production systems in the target countries, so its impact on water availability would be minimal. However, it would stabilize olive production, which currently may vary by a factor of 10 year-to-year due to varying weather patterns. Stabilization of olive production is also expected. In both countries, the olive sector has been expanding very rapidly in the last few decades. Growth in Syria started in the Eighty’s at very fast rate (5% per year) and currently it is at 3%, with actual cropped area of 530,000 ha. Morocco experienced a similar growth rate in the new olive plantings, bringing a total acreage of about 600,000 ha at present.

II. Objectives and outputs

Goal: The goal of the project is to increase the revenues of olive farmers by increasing production through the adoption of advanced irrigation management. The specific objectives of the project are to (i) to increase yield of olive groves in the target areas by using advanced irrigation strategies; (ii) minimize yearly fluctuations in yield, and securing more stable farm income and (iii) increase water productivity of irrigated olive in the target countries.

Outputs: (1) Demonstration of the potential of advanced irrigation for increasing olive yield above current levels in rainfed olive groves and in conventionally irrigated groves; (2) Demonstration of the potential of regulated deficit irrigation (RDI) for increasing production under irrigation with a limited water supply; (3) Demonstration of a) the advantages of irrigation on the quality of olive fruits and b) the lack of detrimental effects on the quality of olive oil; (4) Dissemination & training based on the new information on olive irrigation management obtained in the regions where pilot plots are established. A detailed schematic representation of the project outputs is presented in the figure below.

Table 1 illustrates the project work plan during the whole implementation duration (2010-2014), activity implementation schedule per semester (2010-2014), while Table 2 presents the Project Work plan for the second year (2011).
III. Progress and achievements during the period of January 2011-December 2011

III.1 Training and monitoring

The second year (January-December 2011) of the project duration marked a number of events, including a one-week training course on ‘innovative methods and tools of irrigation’ that was organised in Marrakesh in March 2011, to which participated engineers and technicians from the project support teams in Morocco and Syria. The period also featured a monitoring visit by IOC at the issue of the training course in Marrakesh to the project implementation sites in Morocco. As well, some highlights of planned activities at the project sites in Morocco and Syria included the establishment of the four demonstration plots; two in Morocco and two in Syria.

The purpose of the training course on ‘innovative methods and tools of irrigation’ was to deliver an advanced training course that will improve the human capacity of the NARS of Morocco and Syria in the domains of innovative methods of irrigation management of olive trees. The expected outputs were as the following (i) 15 researchers and technicians from the NARS of Morocco and Syria trained on innovative tools and methods of irrigation management of olive trees; (ii) research activities and plans improved and good quality data collected and (iii) research capacity of the NARS of Morocco and Syria on new methods of irrigation of olive trees increased. The course brought up theoretical and practical knowledge, and counted on good teaching material specifically produced for the purpose of the training. Trainers were from ICARDA and IAS-CSIC in Cordoba (Spain).

On the other hand, a monitoring visit to the project implementation sites in Morocco was achieved by IOC. The purpose of the mission was:

   a. Check the effectiveness and organisation on the training activities;
   b.Ascertain the project progress according to the planned activities for the first year of the project duration;
   c. Ascertain the application of proper and valid research protocols in the pilot plots in both partnering countries;
   d. Visit the project sites in Morocco.

It was concluded by the IOC team that the training was very useful and helped implementing the project different activities accurately. It also was concluded the both countries compiled fully with the work plan of the first year and acted responsibly when executing all the component of this first stage of the project. The IOC team assured that the four pilot plots in Morocco and Syria were well equipped with the required irrigation equipment and other field management material. However, the recent unrest in Syria that start to appear in April 2011 made it difficult to continue the planned activities in Jilin research station and Tafas farmer’s plot near the city Daraa in southern Syria. In spite of purchasing and installing the required irrigation equipment for these two pilot plots, other planned activities marked in Component 2 (Irrigation and Field Management) were not duly achieved in Daraa for the above mentioned reasons. For that reason, we will present in this report results from the project implementation in Saada and Tassaout pilot plots in Morocco, while for Syria only results from Surbaya pilot plot near Aleppo will be presented.
It is also worth to mention that the project Management team at ICARDA (Drs Theib Oweis, Fadi Karam and Mohammed Karrou) accomplished regular visits to the project sites in Morocco and Syria during the second year of the project duration. Regular meetings were held with the project support teams in both countries, as well as with farmers’ groups hosting the demonstration plots in their groves.

On the other hand, the first coordination meeting of IRRIGAOLIVO Project was held at the premises of the Institut National de la Recherche Agronomique (INRA), Rabat, Morocco, on 30 November 2011. Representatives of the different partnering institutions participated in the meeting. It was agreed that a mid-term evaluation of the project will be undertaken by IOC and CFC in spring 2012.

III.2 Description of the technical activities

The project annual work plan of the second year of the project implementation is presented in Table 1. During this period, the following activities were achieved:

COMPONENT 1: ESTABLISHMENT OF PILOT PLOTS

Objective: The pilot plots aim at demonstrating the potential of using advanced irrigation techniques for increasing olive yield above current levels in rainfed olive groves and in conventionally irrigated groves. They also aim at demonstrating the benefits of adopting regulated deficit irrigation (RDI) for increased production under irrigation with a limited water supply.

Four pilot plots were established: two in Morocco (Tessaout and Saada) and two in Syria (Surbaya and Daraa). Upon the recommendation of the Moroccan appointed team in the project, the cultivar ‘Menara’ was used instead of ‘Picholine Marocaine’ in the Saada pilot plot near Marrakech, as an integral part of Activity 1.1. In addition, a pilot plot was established in Tafas (southern Syria) in one farmer’s private plot after the purchase and installation of the drip irrigation system and its accessories (filtering, fertigation, etc...) (Activity 1.5). While the bulk of activities under Component 1 (Activities 1.1 through 1.5) were completed in the first year, it is expected some additional activities will be carried out during the second year, mainly in Daraa and Tafas plots in Syria, where due to the recent unrest in the country some activities still needed for the full preparation of the plots.

**Activity 1.1** Planting of a new plot with the local cultivar “Picholine marocaine” in the Saada farm, near Marrakech

**Activity 1.2** Purchase and installation of a drip irrigation system (including pumps, filters, gauges, fertigation injectors and tanks, etc.) in the Saada plot

**Activity 1.3** Purchase and installation of a drip irrigation system (including pumps, filters, gauges, fertigation injectors and tanks, etc.) in the Tessaout plot.

**Activity 1.4** Purchase and installation of a drip irrigation system (including pumps, filters, gauges, fertigation injectors and tanks, etc.) in the Surbaya station plot.

**Activity 1.5** Purchase and installation of a drip irrigation system (including pumps, filters, gauges, fertigation injectors and tanks, etc.) in the Daraa plot and the Tafas private plot
COMPONENT 2: IRRIGATION MANAGEMENT AND FIELD MANAGEMENT

Objective: Correct irrigation management of the PPs following state-of-the-art irrigation strategies proposed in this project. Suitable management of pests, disease and weed control, fertilisation, and tillage, aimed at avoiding interference with the irrigation effects on yields.

The following activities were planned under Component 2, as a continuation of the first semester (Table 1). Activities 2.1 through 2.4 were conducted in the four demonstration plots of Tessaout and Saada in Morocco, as well as Surbaya and Daraa in Syria. Activity 2.5 was not carried out in the olive pilot plot in Saada since plantations in this site are young. Moreover, it is planned that during the second year of the project, Activities 2.1 through 2.5 will be closely monitored in Tafas private plot after the purchase and installation of the drip irrigation system and its accessories (filtering, fertilization, etc…) were achieved in the first year.

Activity 2.1 Irrigation management
Activity 2.2 Fertilisation management
Activity 2.3 Pests, diseases and weed management
Activity 2.4 Tillage management
Activity 2.5 Harvest operations (except in Saada domain)

COMPONENT 3: FIELD SAMPLING AND DATA ANALYSIS

Objective: Preservation of the correct orchard water status of the PPs during the whole irrigation season, avoiding excessive water stress during sensitive periods, which could jeopardise or reduce the expected orchard performance. Control of tree performance and quality of the final product to verify the accomplishment of the desired quantitative and qualitative goals.

During this periodic report, the following activities were planned under Component 3, as a continuation of the first semester of year one activities (Table 1). A continuous monitoring of the SWC and tree water status (Activity 3.1) was made in all pilot plots, except in Daraa in Southern Syria as a result of the security instability in that region following the unrest that disquiets the country starting early spring 2011. It is planned that the post-harvest chemical analysis of oil quality indicators (oil %, acidity, oleic acid, etc…) will be made after the harvest season of autumn 2012 is ended. These analyses are expected to complete during winter 2012 in order to prepare a panel for organoleptic evaluation of the harvest oil (Activity 3.2). After that, oil samples from the newly milled olive originating from the pilot plots will be prepared for further distribution among visiting olive farmers and growers in the respective project areas in Morocco and Syria.

Activity 3.1 Continuous monitoring of soil water content and tree water status; leaf and fruit sampling for early detection of pests and disease attacks

Activity 3.2 Post-harvest chemical analysis of oil quality indicators; organization of panels for organoleptic evaluation
**Activity 3.3** Preparation of oil samples coming from the PPs for distribution among visiting farmers.

**COMPONENT 4: TRAINING AND TECHNOLOGY DISSEMINATION**

**Objective:** Training of technicians and extension officers in the determination of water requirements in olive orchards and design of efficient irrigation scheduling plans. Close monitoring of the pioneer farmers who will first adopt the new irrigation systems and practices. Dissemination and demonstration among farmers of the benefits of advanced irrigation systems and rational use of irrigation water.

During the second half of year one, a one-week training course on the calculation of crop water requirements of olive tree was organised in Marrakesh in March 2011 (Activity 4.2). It is planned to organise the second year course at ICARDA in spring 2012. In addition, monitoring and tutoring of the farmers switching to improved irrigation practices, drip or mini-sprinkler (Activity 4.4) will be effectuated during the 2011 growing season, as well as a continued technical support to collaborating national institutions in both countries (Activity 4.5).

**Activity 4.1** Design and printing of manuals, handbooks, guides to be distributed to farmers during the field days

**Activity 4.2** Two or three courses on calculation of olive water requirements targeted to local extension officers. Courses given by teachers appointed by the PEA

**Activity 4.3** Field days targeted to local farmers. The project will be advertised in the local area; on the dates of the field days transportation will be provided for the farmers to the PPs, and meals too. During the field days the farmers will be informed of the benefits of the new irrigation systems and strategies, and instructed on how to put them in practice. Printed manuals will be distributed

**Activity 4.4** Close monitoring and tutoring of the farmers who decide to switch to irrigation or to improve their irrigation practices with the proposed systems and methods

**Activity 4.5** Supervision and technical support to collaborating national institutions through regular visits

**COMPONENT 5: PROJECT MONITORING AND SUPERVISION**

**Objective:** To monitor and supervise the development of project activities according to project plans, and to ensure that project objectives are achieved in a timely manner.

An important step of the project implementation under Component 5 is the organisation of the annual meeting of the Project Coordinating Committee (PCC) (Activity 5.1). As well, the annual work plan and budget (Activity 5.2) will be made ready by the Project Coordinator in April 2012. It is likely to have during the second half (December 2011 – May 2012) of the second year a mid-term evaluation of the project (Activities 5.3 & 5.5). As marked in the Project Appraisal under Section H (Project monitoring and evaluation, reporting and supervision), ‘The CFC will carry out regular monitoring of the project, in coordination with IOC, which also will carry out supervision in its capacity as Supervisory Body for the project”. The date of the mid-term evaluation of the project will be set by CFC and IOC. As well the project implementing agency (ICARDA) will provide during the second year two six-month
reports, the first at the end of November 2011, covering the reporting period of June-November 2011, and the second at the end of May 2012, covering the reporting period of December 2011-May 2012.

**Activity 5.1** Organise annual meeting of the Project Coordinating Committee

**Activity 5.2** Preparation of Annual Work Plans and Programme Budgets

**Activity 5.3** Mid-term and final evaluation of the project

**Activity 5.4** Submission of six-monthly and annual progress reports; annual financial and independent auditor’s report

**Activity 5.5** Annual monitoring visit and report by the CFC.
Table 1: Project work plan during the 2010-2011 implementation years

<table>
<thead>
<tr>
<th>Component 1</th>
<th>Establishment of pilot plots for demonstration</th>
<th>2010</th>
<th>2011</th>
</tr>
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<tbody>
<tr>
<td>Type of activity</td>
<td></td>
<td>JUN</td>
<td>JUL</td>
</tr>
<tr>
<td>Activity 1.1</td>
<td>Planting of new plot with local cultivar “Picholine Marocaine” in the Saada farm</td>
<td></td>
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<tr>
<td>Activity 1.2</td>
<td>Purchase &amp; installation of drip irrigation system in the Saada plot</td>
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<tr>
<td>Activity 1.3</td>
<td>Purchase &amp; installation of drip irrigation system in the Tessaout plot</td>
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<tr>
<td>Activity 1.4</td>
<td>Purchase &amp; installation of drip irrigation system in the Surbaya station plot</td>
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<tr>
<td>Activity 1.5</td>
<td>Purchase &amp; installation of drip irrigation system in the Dara’a plot and the Tafas private plot</td>
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<table>
<thead>
<tr>
<th>Component 2</th>
<th>Irrigation management and field management</th>
</tr>
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<tbody>
<tr>
<td>Type of activity</td>
<td></td>
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<tr>
<td>Activity 2.1</td>
<td>Irrigation management</td>
</tr>
<tr>
<td>Activity 2.2</td>
<td>Fertilization management</td>
</tr>
<tr>
<td>Activity 2.3</td>
<td>Pest, disease management &amp; weed control</td>
</tr>
<tr>
<td>Activity 2.4</td>
<td>Tillage management</td>
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<td>Activity 2.5</td>
<td>Harvest operations (except Saada domain/Morocco)</td>
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<table>
<thead>
<tr>
<th>Component 3</th>
<th>Field sampling and data analysis</th>
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<tbody>
<tr>
<td>Type of activity</td>
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<tr>
<td>Activity 3.1</td>
<td>Monitoring of SWC &amp; tree water status. Leaf and fruit sampling for pest &amp; disease early detection</td>
</tr>
<tr>
<td>Activity 3.2</td>
<td>Post-harvest chemical analyses of oil quality indicators. Organoleptic evaluation.</td>
</tr>
<tr>
<td>Activity 3.3</td>
<td>Preparation of oil samples coming from the PPs for distribution among visiting farmers</td>
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<table>
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<tr>
<th>Component 4</th>
<th>Training and technology dissemination</th>
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<td>Type of activity</td>
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<td>Activity 4.1</td>
<td>Design &amp; printing of learning materials to farmers during the field days</td>
</tr>
<tr>
<td>Activity 4.2</td>
<td>Two or 3 extension courses on olive WR calculation</td>
</tr>
<tr>
<td>Activity 4.3</td>
<td>Field days on new irrigation systems and strategies, &amp; how to put them in practice</td>
</tr>
<tr>
<td>Activity 4.4</td>
<td>Monitoring &amp; tutoring of farmers deciding to switch to modern irrigation</td>
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<tr>
<td>Activity 4.5</td>
<td>Supervision &amp; technical support to collaborating national institutions</td>
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<tr>
<th>Component 5</th>
<th>Project monitoring and supervision</th>
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</thead>
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<tr>
<td>Type of activity</td>
<td></td>
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<tr>
<td>Activity 5.1</td>
<td>Organize annual meeting of the Project Coordinating Committee</td>
</tr>
<tr>
<td>Activity 5.2</td>
<td>Preparation of Annual Work Plans and Program Budgets</td>
</tr>
<tr>
<td>Activity 5.4</td>
<td>Submission of six-month &amp; annual progress reports; annual financial &amp; independent auditor’s report</td>
</tr>
<tr>
<td>Activity 5.5</td>
<td>Annual monitoring visit and report by the CFC</td>
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III.3. Demonstrations trials

III.3.1 Morocco

Description of the main activities achieved in 2011

During the second year of the project implementation duration, field experiments were conducted as planned during the inception workshop at ICARDA HQs in Aleppo in April 2010. As well, chemical and organoleptic characteristics of the oil produced in the 2010 growing year were analyzed.

The course organized by ICARDA in March 2011 for the project resource teams in Morocco and Syria contributed to correct some aspects of the trials (see layout and design below).

Case of Saada pilot plot

- The increase of the density of the young plantations (8 x 8 to 8 x 4) to align with current trends of olive cultivation intensification in the area. This will be done next autumn in order to avoid disruption of the trial; Planting will be based on plants of the same height as those of the each elementary plot.

Case of Tassaoute pilot plot

- The increase of the number of trees per treatment to avoid the border effect (Figure 1)
- Change in the number of drippers per tree, distance from the tree, etc...
- Finally, the control program of irrigation has been modified in the light of the program available to us by Dr. Lucas Testi (IFAPA Spain) integrating climate data and soil characteristics, tree height and the average diameter of the canopy.

The modified layout and treatments of the demonstration trials are described in figure 1.
**Figure 1**: Design of pilot plot modified (to resolve borders problem)
a) Performance of young olive trees under deficit irrigation in semi-arid area of Morocco

Scarcity of water in semi-arid areas of Morocco decreases water availability for crops, including fruit trees. Olive tree, characterized by its limited water requirements and usually grown under rainfed conditions, is actually extended to irrigated land. However, due to limited water resources, the objective now is to replace the traditional irrigation methods with water saving systems such as drip irrigation. These systems offer the possibility of frequent irrigation at low application rates and intensities and the application of water directly to the root zone of the trees without wetting the entire soil surface near the rows of the tree. Furthermore to these methods, previous research has shown that deficit irrigation regimes could be applied under olive orchards without any significant negative effect on fruit yield.

The main objective of this study was to assess the effect of drip irrigation with full and deficit water regimes on the growth of young trees compared to traditional irrigated system with flooding method.

Material and Methods

The trial was carried out at Saada experiment station located 9 km from Marrakech city. The climate is a typical Mediterranean semi-arid with a hot and dry summer.

The olive orchard was planted on a 1.67ha plot. The experimental plot was sub divided into two main plots, one for drip irrigation system on 1.15 ha (Photo 1) and the other for traditional irrigation with flooding (Photo 2) on 0.52 ha. Trees in the orchard had a spacing of 8 x 8 m.

Photo 1: Young olive trees under drip irrigation system at Saada station
On the drip irrigation plot, two irrigation regimes were compared: deficit irrigation of 70% ETc and full irrigation of 100% ETc (actual crop evapotranspiration). ETc was calculated according to the following equation:

\[ ETc = ETo \times Kc \]

Where ETo is the reference evapotranspiration and Kc is the Penman Monteith crop coefficient for olive tree.

The amount of irrigation applied in the flooding treatment was 538 mm. The irrigation drippers varied among drip irrigation regimes. There were 5 emitters per tree in the case of 100% ETc and 4 emitters per tree in the case of 70%ETc. The latter were equally spaced around each tree. The amount of irrigation applied under drip irrigation treatments was 116 mm for 100% ETc and 81 mm for 70% ETc irrigation regimes.

The assessment of young olive trees growth was conducted on 11 November 2011 by measurement of the following parameters:

- The section of the trunk
- The height of trees
- The maximum canopy diameter

The growth parameters were measured on 21 young olive trees per treatment and replication.
Results and Discussion

Table 2 shows a significant difference in growth characteristics of young olive trees between drip and traditional irrigation system with submersion. On average, trunk section was 5.6 cm under drip irrigation system against 3.5 cm in submersion irrigated plot. The height of young olive trees under drip-irrigated system was 27 cm more than that obtained under submersion-irrigated system. When we compared the two irrigation regimes under drip irrigation system, we observed that trunk section and the tree height were not affected by continuous deficit irrigation regime. However, deficit irrigation regime significantly increased canopy diameter compared to full irrigated regime.

Table 2: Growth parameters under drip irrigation system with two irrigation regimes (100% ETc and 70%ETc) and traditional irrigated system with flooding

<table>
<thead>
<tr>
<th>Irrigation regimes</th>
<th>Trunk section (cm)</th>
<th>Height (cm)</th>
<th>Canopy diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% ETc (drip irrigation)</td>
<td>5.61a</td>
<td>121.82a</td>
<td>59.71b</td>
</tr>
<tr>
<td>70% ETc (drip irrigation)</td>
<td>5.58a</td>
<td>121.57a</td>
<td>67.26a</td>
</tr>
<tr>
<td>Submersion (traditional irrigation)</td>
<td>3.55b</td>
<td>94.23b</td>
<td>38.22c</td>
</tr>
</tbody>
</table>

In the same column, values followed by different letter are significantly different at P<0.05

Conclusions

The introduction of drip irrigation system under young olive orchard improved growth performance of young olive trees compared to traditional irrigated system with flooding. Deficit irrigation did not have any negative effect on growth performance of young olive trees.

b) Response of Mature olive trees to switching from conventional to drip irrigation

Morocco is one of the traditional producers of olive in Mediterranean basin. Olive trees are commonly cultivated without irrigation in areas receiving 400 – 600 mm average rainfall; however, for high yields, 600 to 800 mm are required (www.FAO.org). The irrigation of olive trees is one of the strategies adopted by farmers to increase and stabilize olive yields compared to rainfed areas. Nevertheless, due to the continuous decrease and irregularity of rainfall in semi-arid areas, the available water for olive trees is decreasing and consequently, higher and stable yields are not achieved. In Morocco, irrigated live production area has increased in the last decade and now around 35% of olive orchards in the country are irrigated. However, a large area is cultivated under traditional inefficient surface irrigation system (Erraki et al., 2010) which leads to large water losses. Therefore, new irrigation methods are being introduced to overcome the inefficient use of irrigated water and to save water resources. To promote water saving irrigation techniques, the Moroccan government provides financial supports to the farmers who want to convert surface irrigation to new water-saving irrigation methods such as drip irrigation which is considered to be more water-efficient than the gravity method. However, to convince farmers to adopt drip irrigation methods, research and development
institutions are together conducting demonstration trials and field-days to show the farmers the advantages of the technique. The objective of this study is to compare drip irrigation with flooding irrigation commonly used by the farmer to grow olives in the region.

**Material and Methods**

The experiment was conducted in a 35-year old irrigated olive orchard (cv. Picholine Marocaine) at the experiment station of INRA in Tessaout, Marrakech region. The soil is classified as silty-clay. The climate is Mediterranean with hot and dry summers and with an average rainfall of 266 mm.

Two irrigation methods were applied - drip irrigation with two irrigation regimes, and flood irrigation same as traditional system used by most of the farmers. The planting density was 208 trees ha$^{-1}$ in the case of flood irrigation treatment with a row spacing of 8 m x 6 m and 156 trees ha$^{-1}$ for drip irrigation treatment with 8 x 8 m row spacing.

Drip irrigation and traditional irrigation systems are used in two adjacent plots. The drip irrigation plot had an area of 1 ha and the traditional irrigation plot had an area of 0.5 ha. The drip irrigation experimental plot included 12 subplots (two tillage treatments x two irrigation regimes x three replicates). The two irrigation regimes under drip irrigation systems are: 100% of crop evapotranspiration (ETc), and 70% of ETc; and the two tillage treatments are: deep tillage and minimum tillage. Each replicate included 10 trees. A deep tillage operation was conducted on 13 January 2011 to 60 cm depth and 1 m from the trunk. The minimum tillage consisted of one pass of chisel on 12 January 2011.

The ETc was calculated using the equation:

$$ETc = ETo \times Kc$$

Where $ETo$ is the reference evapotranspiration and $Kc$ is the Penman Monteith crop coefficient for olive tree.

The $ETo$ values were obtained from a weather station installed at the experiment station of Tessaout. The amount of irrigation applied in the flooding treatment was 600 mm. The number of drippers varied among drip irrigation regimes. There were 16 emitters per tree in the case of 100% ETc and 12 emitters per tree in the case of 70% ETc. The latter were equally spaced around each tree. The amount of irrigation applied under drip irrigation treatments was 203 mm for 100% ETc and 137 mm for 70% ETc irrigation regimes, respectively.

A severe pruning was performed from 22 to 28 November 2010 (Photo 1). Weed control was performed using a minimum tillage operation between row trees (Photo 2).

A randomized complete block (RCB) design was used with three replications per irrigation regime per tillage treatment in the case of drip irrigation system. In the case of traditional irrigation plot, two adjacent blocks were: one with 100% flooding irrigation and the other with conventional surface irrigation.

Due to the severe pruning of trees, it was difficult to label the branches, as expected. As in each elementary plot, we sampled 8 twigs from 2 trees at various phenological stages.
The parameters measured were:

- The rate of flowering, measured on twigs collected 8 April 2011
- The number of flowers per cluster, and the rate of hermaphrodite flowers on 28 April 2011
- The rate of fruit set on 10 May 2011
- The rate of fruit and length of the new formed shoots on 22 June 2011

Yields were estimated on the entire trees per block. They were 30 trees per replication in the case of traditional irrigated system and 10 trees per replication in the case of drip irrigation system.

To study the fruit and oil parameters, a sample of 4 kg of olives per tree (three trees per plot) was harvested on 4 November 2011. Fruit components were measured, and then they were triturated with Abencor to perform the oil analysis.

The weight of the fruit and stones were measured on 100 randomly selected fruits. The fruit weight, flesh and the ratio flesh/stone were determined.

The maturity index was performed on a sample of 100 fruits. The fruits of each color class were counted and the maturity index was calculated using the method developed by Uceda (1975).

The oil rate was determined by the extraction of oil by the “Abencor” system. The extracted oil will be analyzed by December 2011 (chemical and sensorial analysis).

(a)  
(b)  

Photo 3: Severe pruning on 35-year old olive trees (a) and minimum tillage to weed control (b) in Tessaout station.
Results and Discussion

The climatic conditions of the experimental site were characterized by an average rainfall of 303 mm falling between December 2010 and October 2011 (Figure 2). The higher rainfall amount was in the month of May with 77 mm.

![Cumulated rainfall per month](image1)

**Figure 2**: Monthly rainfall measured at Tessaout experimental station

Figures 3 to 7 show various growth and fruit parameters measured during the current 2011 olive growing season in Morocco.

![Shoot length](image2)

**Figure 3**: Shoot length on 22 June 2011 under drip (black color) and flood irrigation systems (grey color) at Tessaout pilot plot
**Figure 4:** Flowering rate under drip (black color) and flood irrigation systems (grey color) at Tessaout pilot plot

**Figure 5:** Flower number per cluster under drip (black color) and flood irrigation systems (grey color) at Tessaout experimental station
For vegetative growth (newly formed shoots), the start-up has been observed in the plot during the first week of March. During 20-22 June 2011, newly formed shoots ranged between 6 and 8 cm length. Statistical analysis shows that there is no significant difference between treatments. Taking into account the severe pruning of trees, the lateral (side) shoots were almost insignificant.

The rate of flowering was measured on twigs one year old by calculating the ratio of flower buds to the total number of buds. We observed that this rate varied between 35 and 41% with no significant differences between the irrigation regimes.
The number of flowers per cluster varied from 14 to 17 which were slightly less than 18 flowers per cluster considered as the usual number observed for the Picholine marocaine variety. We found no significant effect of water regimes on the number of flowers per cluster, the rate of hermaphrodite flowers and the rate of fruiting (measured on 22 June 2011).

We note that the various parameters of growth and fruit did not differ with the variation of water regime. This is due to significant amount of rainfall received between March and May at the site. However, growth monitoring and pomology fruit to maturity could result in differences between treatments. The most significant result is that there is no difference between the two water regimes of drip irrigation (100% and 70%).

**Yield**

The average estimated yields were 1.5, 0.3 and 1.15 t ha\(^{-1}\) for deep tillage with drip irrigation system, minimum tillage with drip irrigation system and traditional irrigation system, respectively. In general, fruit yields were lower than those encountered in the region, and the yield observed under minimum tillage with drip irrigation were less than those observed in rainfed olive system in Morocco. These short-term low yields could be related to the severe pruning and alternate bearing.

![Figure 8: Fruit yield under drip (black color) and flood irrigation systems (grey color) at Tessaout experimental station](image)

Under drip irrigation system, olive yields were slightly higher for 100%ETc irrigation regime than 70%ETc (Figure 2). With deep tillage, average yields were 1.6 and 1.3 t ha\(^{-1}\) for 100%ETc and 70%ETc regimes, respectively. In the case of minimum tillage, a high yield penalty was observed with drip irrigation system and average yield were 0.33 and 0.26 t ha\(^{-1}\) for 100%ETc and 70%ETc regimes, respectively.

Although the amount of irrigation water applied under traditional irrigated system were three times higher than those applied in 100% ETc regime under drip irrigation, olive yield in the last case was only slightly higher than those observed under traditional system.
**Figure 9:** Olive weight under drip (black color) and flood irrigation systems (grey color) at Tessaout experimental station

**Figure 10:** Flesh/stone ratio under drip (black color) and flood irrigation systems (grey color) at Tessaout pilot plot

**Figure 11:** Maturity index of olives harvested on 4 November 2011 under drip (black color) and flood irrigation systems (grey color) at Tessaout pilot plot
**Figure 12:** Oil content (Abencor extraction) of olives harvested on 4 November 2011 under drip (black color) and flood irrigation systems (grey color) at Tessaout pilot plot

**Conclusions**

With lower amount of water applied under drip irrigation than those supplied under traditional irrigated system (with flood irrigation), drip irrigation could have performed better in terms of yield of old olive trees than the traditional irrigation system if deep tillage were applied before the establishment of the system. However, estimated yields of this year cropping season were lower than those of the region. Further research is required to assess the results of the current cropping season and to include other parameters associated with water use.

**References**


III.3.2 Syria

Description of the main activities achieved in 2011

Following the training course on the determination of crop water requirements of olive trees that was held in Marrakesh in March 2011, and based on the recommendations of Drs Luca Testi, Victoria Gonzalez and Francesco Serafini, the experimental design was modified in both Surbaya (Aleppo Province) and Jilline (Daraa Province) experimental stations to conform the new experimental settings. As a result, the studied treatments were reduced from 4 to 2 by eliminating the 66% irrigation of water requirement and the rainfed treatments, while keeping only the full irrigated (100%) and deficit-irrigated at 50% of full soil replenishment treatments.

Surbaya pilot plot (Aleppo Province)

Location: The Surbaya Agricultural Research Station belongs to General Commission for Scientific Agricultural Research (GCSAR). It is located 35 km south of Aleppo city, with an average annual rainfall of 335 mm.

Research title: The impact of different levels of deficit irrigation on olive productivity under drip irrigation system.

Research objectives:

- Determining Olive water requirements at different levels under Drip Irrigation.
- Determining crop coefficient $K_c$ and its changes according to olive phenology.
- Finding out irrigation efficiency, and water use efficiency WUE.
- Studying the relationship between yield and water, according to different treatments.

Experimental design: The experiment included two water treatments: 1st is given 100% of crop water requirement, and the 2nd treatment at 50% of crop water requirement (Figure 13).

Trees spacing: 6 m x 6 m.

Trees’ age: 21 years.

Irrigation system: In-line drip irrigation, 8 drippers/tree for the 1st and 2nd treatment, with a discharge of 8 L/dripper/hour, where irrigation duration for the 2nd treatment is 50% of 1st treatment irrigation time.

Fertilization system: fertigation using Venturi-type fertilizer injector.

Studied cultivars: Soranyi and Qais
**Figure 13:** The experimental design of the on-farm trial at *Surbaya* research station/Aleppo
Jilline pilot plot (*Daraa Province*)

**Research station field:**

**Location:** *Jillin* Agricultural Research Station, which belongs to General Commission for Scientific Agricultural Research (GCSAR), it is located 25 km North of Daraa city, with an average annual rainfall of 400 mm.

**Research title:** The impact of different levels of deficit irrigation on Olive productivity under drip irrigation system.

**Research objectives:**

- Determining Olive water requirement at different levels under Drip Irrigation.
- Determining crop coefficient KC and it's changes according to olive phenology.
- Finding out irrigation efficiency, and water use efficiency WUE.
- Studying the relationship between yield and water, according to different treatments.

**Experimental design:** the experiment included two water treatments: 1\textsuperscript{st} is given 100\% of crop water requirement, while the 2\textsuperscript{nd} is given 50\% of crop water requirement (Figure 14).

**Trees spacing:** 8 m x 8 m.

**Trees’ age:** 29 years.

**Irrigation system:** In-line drip irrigation, 8 *drippers/tree* for the 1\textsuperscript{st} and 2\textsuperscript{nd} treatment, with a discharge of 8 L/dripper/hour, where irrigation duration for the 2\textsuperscript{nd} treatment is 50\% of 1\textsuperscript{st} treatment irrigation time.

**Fertilization system:** fertigation by using *Dosatron*-type fertilizer injector.

**Studied cultivars:** *Soranyi and Jlott*
Figure 14: The experimental design of the on-farm trial at Jillin/Dara’a (Agricultural Research Station)

B.1.2.2) Farmers field:

Location: Al Asha’ri, which belongs to Tafas Village, it is located 16 km North West of Daraa city, with an annual rainfall average of 400 mm.

Research title: The impact of different levels of deficit irrigation on Olive productivity under drip irrigation system.

Research objectives:

- Determining Olive water requirement at different levels under Drip Irrigation.
- Determining crop coefficient $K_c$ and its changes according to olive phenology.
- Finding out irrigation efficiency, and water use efficiency WUE.
- Studying the relationship between yield and water, according to different treatments.

Experimental design: the experiment included two water treatments: 1st is given 100% of crop water requirement, while the 2nd is given 50% of crop water requirement (Figure 15).

Trees spacing: 10 m x 10 m.

Trees’ age: 45 years.
**Irrigation system:** In-line drip irrigation, 8 *drippers/tree* for the 1st treatment and 4 *drippers/tree* for the 2nd treatment. Single discharge of 16 L/dripper/hour. Irrigation duration for the 1st and 2nd treatment is equal.

**Fertilization system:** fertigation by using *Dosatron*-type fertilizer injector.

**Studied cultivar:** Soranyi

![Diagram](image)

**Figure 15:** The experimental design of the on-farm trial at Al A’asha’ri/Dara’a (farmer)

**On-farm research activities**

Due to the unrest and unsafe conditions that prevailed in the province of Daraa in spring 2011, the project team found some difficulties in achieving project scheduled activities, although we could achieve the following:

- Installing a new drip irrigation system in Dara’a, in both of the agricultural research center and in the field of the farmer, the two systems are equipped with a good head unit including fertilizer injector.

- Crop water requirement for the studied treatments, is calculated according to soil moisture follow up by neutron probe system in Aleppo province, while in Dara’a province it is done by sampling method, because of the difficulty of buying a new neutron probe system (mentioned in the project Document).

- Irrigation was applied in its suitable times (when soil moisture declines to 80% of FC in the 1st treatment), water balance is calculated, and all phonological stages are followed up, also
fertigation is applied by injecting needed fertilizers though the irrigation system (via Dosatron fertilizer injector). Finally plant-water relationship is being studied.

– Making a deal with the farmer in al Asha’ari/Dara’a to guarantee his rights in compensating him the loss in production between the 100% and 50% water treatment, and also to support him by the needed soluble fertilizers for the season.

The deal also guarantees the project team rights in the commitment of the farmer to follow up all rules given to him (irrigation frequency and quantity……).

– Purchasing desk supplies (PCs, Laptops, Digital Cameras, printers) needed for the achievement of project activities, including the preparation of tow training halls in both of Aleppo and Dara’a.

- Buying some research equipment (Porometers, Pressure membrane systems, Electronic agrometeorological stations) needed for the achievement of research activities.

– A visit by the coordinator and Dara’as project team to surbaya experimental station in Aleppo, in the domain of exchanging experiences (April 2011), while another visit will be done in the future by the coordinator and Aleppos project team to Jillin experimental station in Aleppo and to the farmers field in Al Asha’ari for the purpose.

**Results**

We present here the results obtained from the experimental groves in Surbaya research station near Aleppo in Northern Syria only. The results from Jillin research station are nor reported in this document. Figure 16 shows seasonal water consumption of olive trees under full irrigation regime (100% of soil replenishment) and deficit-irrigated regime (50% of soil replenishment). Total water consumption amounts 322 and 215 mm, respectively, for average daily evapotranspiration of 1.5 and 1.0 mm/day. Figure 17 illustrates the seasonal water balance of olive under full and deficit irrigation. Moreover, Figure 18 gives a comparison of daily evapotranspiration (ET) of olive trees under full and deficit irrigation conditions.

On the other hand, Figure 19 shows the daily trend of crop coefficient for olive trees, calculated as the ratio of actual evapotranspiration on potential evapotranspiration. The latter being calculated using the FAO-Penman Monteith 24 hours equation, over a total growing period of 214 days. Figure 8 demonstrates that maximum crop coefficient was obtained at fruiting set for a value of 0.74, while average $K_c$ along the growing season was 0.58. Figure 20 displays olive production at Surbaya research station for both two common olive cultivars Soranyi and Qaisi. As marked in Figure 9, production levels of Qaisi cultivar were under full and deficit irrigation regimes (100 and 50% higher than those observed for Soranyi cultivar. Further results still needed as per the quality of olive oil from the different project sites.
Figure 16: Seasonal and daily evapotranspiration of the fully-irrigated control (above) and the deficit-irrigated treatment (below)
Figure 17: Seasonal water balance components of olive trees under full irrigation (above) and deficit irrigation (below)
**Figure 18:** Average water consumption of well-irrigated (100% FC) olive trees during the 2010 growing season at Surbaya research station in Northern Syria

**Figure 19:** Number of growing days (total of 214 days)
Conclusions
The results obtained during the 2011 growing year for the water use of olive trees and quantitative yield will be consolidated by the qualitative results of olive oil. Correlations will be drawn to detect the effect of watering regime on the quality of oil. The results of the oil quality parameters are expected to be finished by the end of the year. A thorough report will then be developed to include the oil quality results.
IV. Burn rate expenditure

A burn rate analysis of the project statement of expenditure up to 30 November 2011 shows that total expenditure is $228,989.0 ($82,268.0 expenditure up to December 2010 + $146,721.0 expenditure from 1 January 2011 to 30 November 2011) against funds received of $175,000. The below table and pie illustrate the expenditure per item of the different budget line up to 30 November 2011.

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<th>Cost category</th>
<th>Budget</th>
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<th>Jan-Nov 2011</th>
<th>Total Expenditures</th>
<th>Remaining Balance</th>
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<td>146,721</td>
<td>228,989</td>
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Funds Status

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<td>Expenditure November 2011</td>
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<tr>
<td>Total Expenditure</td>
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<tr>
<td>Balance available as of Septmeber 2011</td>
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Photo 4: Surface irrigated olive trees at Surbaya Research Station (Aleppo) in Syria

Photo 5: Drip irrigated olive trees at Surbaya Research Station (Aleppo) in Syria
Photo 6: A visit to Jillin Research Station near Daraa (Southern Syria)

Photo 7: A view of the farmers’ groves at Tafas near Dara (Southern Syria)